# DIRECT READING TUBES: A GUIDE TO THEIR USE AND APPLICABILITY IN THE MEASUREMENT OF HAZARDOUS CONTAMINANTS

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## DISCLAIMER

Mention of company name or product does not constitute endorsement by the Ontario Ministry of the Environment.

# Direct Reading Colourimetric Indicator Tubes

Air pollution personnel require a method of evaluating atmospheres that is fast, convenient, relatively inexpensive, gives immediate results and can be operated by semi-skilled workers. Industrial atmospheres and emergency air pollution situations both demand analysis of this nature since an immediate assessment of the contaminant hazard is usually needed. Direct reading colourimetric tubes satisfy most of these requirements.

## Types

Colourimetric analysis of air may be achieved by ambient exposure of chemically treated papers or sealed tubes containing liquid reagents which are sensitive to the contaminant suspected. The intensity of the colour produced by the contaminant is proportional to its concentration in the test atmosphere.

Glass tubes containing solid indicator chemicals are the most convenient and compact of the three types of direct reading apparatus. Within this device, colourimetric reagents are held by adsorbents such as silica gel. (1) These tubes are the subject of the remainder of this report.

## Operation

The solid containing indicator tubes are hermetically sealed by the manufacturer and must be broken at each end when required for use. The tube is then fitted to the manufacturers' precalibrated squeeze pump or syringe and a measured amount of air is drawn through the tube.

The two types of solid tubes are colour-intensity and length-of-stain type tubes. When using colour intensity indicators the final colour of the adsorbent must be compared to an intensity chart to determine the contaminant concentration.

In length-of-stain type tubes the distance the colourimetric reaction has travelled up the tube is proportional to the contaminant concentration. A scale on the tube allows for a simple evaluation of the contaminant intensity. Length-of-stain type tubes are more popular since they are more easily read and are not dependent upon the lighting conditions or the user's colour eyesight as are the colour-intensity tubes. (2)

Contaminant levels found usually vary from user to user because of individual methods in handling the pump or reading the tube. Therefore it is recommended that a standard procedure be undertaken by all personnel. It is worth noting that one type of pump, the Draeger, requires one hand to operate, whereas the M.S.A., Gastec, and Kitagawa require both hands.

The combining of various manufacturers' components (eg. Draeger tube with MSA pump for analyses is not recommended. Colen found errors of 250% due to the interchanging of pumps and tubes. (3) Therefore the use of the same manufacturer's pump and tubes is advised.

Errors of this sort are due to differences in;

1) suction pressures,
2) flow rates,
3) packing densities in tubes,
and 4) type of chemical reaction undergone within tube. (4)

It is possible to connect tubes in series to test for a number of contaminants at the same time. The tubes must not be mutually interfering (ie. benzene indicator reacts with toluene also, therefore these tubes should not be used together) and should be from the same manufacturer.

The user should have an adequate knowledge of which indicator tubes react with a number of other compounds. Otherwise inaccuracies in ambient contaminant concentrations will be reported.

Modified tubes are available for 8 hr. sampling runs. They operate at a lower air flow and may undergo some chemical changes to ensure a regular response throughout the testing period (eg. a dehumidifying layer may be added to prevent moisture buildup). (5)

Tubes are often constructed utilizing different packings. The first is usually a precleaning chemical to remove interfering gases and improve the specificity of the analysis. If a number of different packings are layered the shelf-life of the tube will be reduced. This is due to the diffusion of various chemicals between the layers and subsequent deterioration of the systems' effectiveness.

The shelf-life is also dependent upon the storage temperature. The cooler the tube is kept, the more stable the reactive system will be. Note that high temperatures may be encountered by leaving the tubes in the back of a car on a hot summer day.

TABLE I

Shelf-Life

Shelf Life of Draeger Carbon Monoxide (6)

| Temp. °C | 25 | 50 | 80 | 100 | 125 | 150 |
|---|---|---|---|---|---|---|
| Shelf-Life | 2 yr. | 1/2 yr. | weeks | 1 week | 3 days | 1 day |

Tubes should be transported with a sufficient amount of care to prevent glass breakage and settling of any loosely packed gels. (7)

Basically, the stain length is proportional to the product of the contaminant concentration and the air volume, but in actuality it is also dependent upon a number of additional factors. Such as;

1) gas diffusion coefficients,
2) chemical reaction rates and equilibria,
3) consistency of the tube bore,
4) temperature effects on the degree of reaction,

and 5) Extreme changes in ambient pressure.

Extreme ambient weather conditions should not affect indicator tube effeciency providing certain precautions are taken. (8) Indicator tubes should understandably be sheltered from open rainfall but still be able to perform in 95%

humidity. This is usually possible through the use of a dehumidifying layer within the tube or utilization of materials which are not affected by atmospheric moisture (eg. presaturated silica gel).

Drastic changes in pressure may be corrected by means of a simple mathematical equation;

$$\text{Concentration} = \frac{\text{indication x 1013 m bar}}{\text{actual pressure in m bar}}$$

This equation would be used for readings taken in mines or very high altitudes.

TABLE III (10)
Air Pressure for Various Altitudes and Effect on Reading

| altitude | atmospheric pressure | effect of pressure (concentration 50 ppm Co) |
|---|---|---|
| 2000 meters | 790 mbar | 39 ppm |
| 1500 meters | 840 mbar | 41 ppm |
| 1000 meters | 900 mbar | 44 ppm |
| 0 meters (sea level) | 1013 mbar | 50 ppm |
| -500 meters | 1060 mbar | 52 ppm |
| -1000 meters | 1020 meters | 55 ppm |

Since reaction rates are dependent on temperature, the indicator tube reading may vary in extreme temperatures (eg. very cold weather or stack sampling). Generally, sampling within the 0-40$^{o}$C range will not be noticably influenced by temperature. If the ambient air temperature is below O$^{o}$C the warming of the tube by grasping it within the palm of the hand will maintain an adequate sampling temperature. If the ambient air is too hot the tube can be kept cool by wrapping it in a damp cloth or foam.

## Certification Standards

Due to the wide popularity of the colourimetric detector tubes in industry, the National Institute for Occupational Safety and Health (NIOSH) investigated the reliability and accuracy of a number of brand name tubes and pumps. The results of the study indicated the wide range of erroneous values and deviation from the standard contaminant gas values. Therefore NIOSH adopted a set of performance and quality control standards for commercial gas detector tubes. Upon passing certification standards the indicator tube type will recieve the NIOSH seal of acceptable accuracy. (11)

A condensed listing of the certification standards are given.

1) Detector tube package must include batch number, tube expiry date, storage and operating instructions, and listings of interference compounds.

2) Gas detector tubes must yield results within 25% of true contaminant concentration.

3) Indicator stain must be of good length, clarity, and possess a definitive endpoint to facilitate reproducible readings in length-of-stain type tubes.

Although the accuracy standards appear lenient, they are difficult for the manufacturers to pass. This can be observed from the NIOSH test for chlorine tubes where only 1 out of 5 brands passed the accuracy requirements (See Table IV). It would be advisable for the Ministry of the Environment to use indicator equipment which has received NIOSH certification if possible.

TABLE IV (12)

Accuracy Limits of All Tube Brands
in Measurement of Chlorine

| | Concentration of Test Gas (ppm) | | | |
|---|---|---|---|---|
| Tube Brand | 0.5 | 1.0 | 2.0 | 5.0 |
| A | ± 70% | ±25% | ±25% | ± 25% |
| B | ± 35% | ±40% | ±35% | ±50% |
| C | ±40% | ±50% | ±30% | ±30% |
| D | ±35% | ±25% | ±25% | ±25% |
| E | ±105% | ±40% | ±85% | ±90% |

In conclusion, colourimetric indicator tubes have been found to be a convenient, rapid, and relatively inexpensive method to assess atmospheres which may be contaminated to excessive levels. Although untrained workers are capable of using the tubes and pumps, it would be advantageous for relevant personnel to undertake a short training course in the use of the apparatus and its' limitations (ie. interferences, inaccuracies). Length-of-stain type tubes appear to be the most efficient choice for Ministry of the Environment requirements and, when used correctly, can supply relevant information for assessment of the possible emergency situation at hand.

# APPENDIX I

## List of Tubes and Air Quality Limits

The following table lists available colourimetric tubes with their concentration ranges and the relevant air quality limits for various pollutant compounds.

This is not a complete listing of either compounds or manufacturers. For further information consult specific manufacturers catalogues.

| Contaminant | Available Sampling | Concentration Range $mg/m^3$ | Ontario Environmental Limit $mg/m^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit $mg/m^3$ |
|---|---|---|---|---|
| | Tube | | | |
| Acetic Acid | Drager | 12.5 - 199 | 2.5[1] | 25 |
| | Gastec | 2.5 - 199 | | |
| | MSA | 12.45 - 996 | | |
| Acetone | Drager | 242 - 29,040 | 48[1] | 2400 |
| | Gastec | 237 - 48,400 | | |
| | MSA | 1210 - 24,200 | | |
| | Kitagawa | 480 - 98,400* | | |
| Acetylene | Drager | 540 - 3,240 | 56[1] | - |
| | Gastec | 1080 - 43,200 | | |
| | MSA | 3.24 - 648 | | |
| Acrylamide | | | 0.045[1] | 0.30 |
| Acrylonitrile | Drager | 1.1 - 65* | 2.2[1] | 45 |
| | Gastec | 1.1 - 796* | | |
| | MSA | 11.1 - 332 | | |
| | Kitagawa | 2.0 - 220* | | |
| Alpha Napthol | | | 0.1[3] | |
| Ammonia | Drager | 3.5 - 486* | 3.6[1] | 18.0 |
| | Gastec | .71 - 227,200* | | |
| | MSA | 3.55 - 1,136 | | |
| | Kitagawa | 4.0 - 144,000* | | |
| Antimony | | | 0.075[1] | 0.5 |
| Arsenic | | | 0.075 | 0.5 |
| Asbestos | | | 0.005[3] | |
| Benzene | Drager | 1.63 - 1,340* | 10[1] | 30 |
| | Gastec | .82 - 391* | | |
| | MSA | 16.3 - 652 | | |
| | Kitagawa | 3.0 - 600* | | |
| Beryllium | | | 0.00003[1] | 0.002 |
| Biphenyl | | | 0.06[3] | |

* more than one tube is needed for concentration range.

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| Contaminant | Available Sampling | Concentration Range mg/m$^3$ | Ontario Environmental Limit mg/m$^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit mg/m$^3$ |
|---|---|---|---|---|
| Boron Tribromide | | | 0.1[1] | 10 |
| Boron Trichloride | | | 0.1[1] | 10 |
| Boron Trifluoride | | | 0.005[1] | 3 |
| Boron | | | 0.1[1] | 10 |
| Bromacil | | | 0.03[3] | |
| Bromine | Drager | 1.4 - 200 | 0.07[1] | 0.70 |
| | Gastec | 13.1 - 150 | | |
| | MSA | 33.3 - 1,332* | | |
| Butyl Acrylate | | | 0.1[3] | |
| Butyl Stearate | | | 0.1[3] | |
| Cadmium | | | 0.005[1] | 0.05 |
| Calcium Hydroxide | | | 0.027[1] | 5 |
| Calcium Oxide | | | 0.02[1] | 2 |
| Carbon Black | | | 0.025[1] | 3.5 |
| Carbon Disulphide | Drager | 15.9 - 10,150 | 0.330[1] | 60.0 |
| | Gastec | 15.9 - 17,000 | | |
| | MSA | 11.7 - 3,510* | | |
| | Kitagawa | 15 - 180 | | |
| Carbon Monoxide | Drager | 6 - 82,000 | 6[1] | 55 |
| | Gastec | 5.9 - 468,000 | | |
| | MSA | 10.2 - 3,510* | | |
| | Kitagawa | 11 - 2,200* | | |
| Carbon Tetrachloride | Drager | 31.5 - 314 | 20[1] | 65 |
| | Gastec | 6.3 - 384 | | |
| | MSA | 64 - 1280 | | |
| Cellosolve Acetate (Ethyl Glycol Acetate) | | | 0.1[3] | |

* more than one tube is needed for concentration range.

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| Contaminant | Available Sampling | Concentration Range $mg/m^3$ | Ontario Environmental Limit $mg/m^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit $mg/m^3$ |
|---|---|---|---|---|
| Chlorine | Drager | 0.58 - 14,500* | 0.3[1] | 3 |
| | Gastec | 0.96 - 46 | | |
| | MSA | 1.48 - 295* | | |
| | Kitagawa | 1.0 - 120* | | |
| Chlorine Dioxide | Drager | 0.28 - 4.2 | 0.085[1] | 0.3 |
| | Gastec | 0.92 - 44 | | |
| | MSA | 0.14 - 44 | | |
| | Kitagawa | 3.0 - 60 | | |
| Chloroform | Drager | 125 - 1250 | 1.5[1] | |
| | Gastec | 50 - 487 | | |
| | MSA | 124 - 1990 | 1.5[3] | |
| Chromium (acid) | MSA | 0.05 - 1.4 | 0.030[1] | 0.1 |
| Copper | | | 0.10[1] | 1 |
| Cresols | | | 0.23[1] | 22 |
| Cyclohexane | Drager | 350 - 5,250 | | |
| | Gastec | 528 - 42,240 | 300.00[3] | 1,050 |
| | Kitagawa | 350 - 21,000 | | |
| Decaborane | MSA | 0.05 - 5.0 | 0.05[1] | 0.3 |
| Detergent Enzyme (subtilisin) | | | 0.001[1] | |
| Diazinon | | | 0.009[3] | 0.1 |
| Diborane | Drager | 0.06 - 3.45 | 0.02[1] | 0.10 |
| | MSA | 0.12 - 3.45 | | |
| Dibutyltin Dilaurate | | | 0.10[3] | |
| Dicapryl Phthalate | | | 0.10[1] | |
| Dichlorodifluoro Methane | MSA | 12.6 - 15,100 | 1500.0[3] | 4,950 |
| Dimethyl Disulphide | | | 0.40[1] | |
| Dimethyl Ether | Gastec | 924 - 27,720 | 2.10[3] | |
| Dimethyl Sulphide | Drager | 2.5 - 38.7 | 0.03[1] | 0.5 |

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| Contaminant | Available Sampling | Concentration Range $mg/m^3$ | Ontario Environmental Limit $mg/m^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit $mg/m^3$ |
|---|---|---|---|---|
| Dioctyl Phthalate | | | 0.1[1] | |
| Droperidol | | | 0.003[4] | |
| Dust Fall | | | 8.0[1] | |
| Ethyl Acetate | Drager | 721 - 10,800 | 19[1] | 1,400 |
| | Gastec | 1,470 - 55,000 | | |
| | Kitagawa | 3,500 - 175,000 | | |
| Ethyl Alcohol | Drager | 192 - 5,760 | 19.00[3] | 1,900 |
| | Gastec | 384 - 144,000 | | |
| | MSA | 384 - 19,200 | | |
| | Kitagawa | 1800 - 90,000 | | |
| Ethyl Acrylate | | | 0.0045[1] | 100 |
| Ethyl Benzene | Drager | 132 - 1,760 | 4[1] | 435 |
| | Gastec | 31 - 3,080 | | |
| | MSA | 220 - 2,200 | | |
| 2-Ethyl Hexanol | | | 0.6[3] | |
| Ethylene | Drager | 55 - 2925 | 0.16[1] | |
| | Gastec | 0.2 - 936 | | |
| | MSA | 0.585 - 117 | | |
| Ethylene Oxide | Drager | 45 - 900 | 28.5[1] | 90 |
| | Gastec | 1,800 - 53,900 | | |
| | Kitagawa | 9 - 63,000 | | |
| Fentanyl Citrate | | | 0.00006[4] | |
| Ferric Oxide | | | 0.075[1] | |
| Fluorides (Gaseous) | | | 0.0043[1] | |
| Fluorides (All) | | | 0.0086[1] | 2.5 |
| Formaldehyde | Drager | 0.61 - 50.0* | 0.065[1] | 3 |
| | Gastec | 2.5 - 25 | | |
| | MSA | 1.25 - 125 | | |
| | Kitagawa | 1.5 - 52 | | |
| Formic Acid | Drager | 1.9 - 28 | 1.5[1] | 9.4 |
| | Gastec | 1.9 - 153 | | |

* more than one tube is needed for concentration range.

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|---|---|---|---|---|
| Furfural | | | 1.0[1] | 20 |
| Furfuryl Alcohol | MSA | 100 - 2,000 | 3[1] | 20 |
| Haloperidol | | | 0.003[4] | |
| Hexane | Gastec | 179 - 42,960* | 35.00[3] | 360 |
| | MSA | 179 - 8,950 | | |
| | Kitagawa | 360 - 21,600 | | |
| Hydrogen Chloride | Drager | 1.5 - 30.4* | 0.1[1] | 7 |
| | Gastec | 0.3 - 61 | | |
| | MSA | 3.04 - 760 | | |
| | Kitagawa | 3.0 - 28 | | |
| Hydrogen Cyanide | Drager | 2.2 - 170* | 1.15[1] | 11 |
| | Gastec | 565 - 22,600 | | |
| | MSA | 1.13 - 73 | | |
| | Kitagawa | 2 - 33,000* | | |
| Hydrogen Sulphide | Drager | 1.4 - 99,400* | 0.03[1] | 15 |
| | Gastec | 0.70 - 56,800* | | |
| | MSA | 1.42 - 1,420 | | |
| | Kitagawa | 2.0 - 60,000* | | |
| Iron | | | 0.01[1] | 1 |
| Isopropyl Alcohol | Drager | 250 - 7,500 | 24.0[3] | |
| | Gastec | 500 - 187,000 | | |
| | Kitagawa | 245 - 49,000 | | |
| Isopropyl Benzene | | | 0.1[4] | |
| Lead | MSA | 0.05 - 6.3 | 0.01[1] | 0.15 |
| Lead in Dustfall | | | | |
| Lithium Hydrides | | | 0.0075[1] | 0.025 |
| Lithium | | | 0.060[1] | |
| Magnesium Oxide | | | 0.10[1] | 10 |
| Malathion | | | 0.1[3] | |

* more than one tube is needed for concentration range.

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| Contaminant | Available Sampling | Concentration Range mg/m$^3$ | Ontario Environmental Limit mg/m$^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit mg/m$^3$ |
|---|---|---|---|---|
| Maleic Anhydride | | | 0.1[4] | |
| Manganese | | | 0.10[1] | 0.10 |
| Mercaptans | Drager | 5.0 - 260 | 0.02[1] | 1.0 |
| | Gastec | 1.03 - 144 | | |
| | MSA | 1.03 - 205 | | |
| Mercaptobenzothiazoledisulphide | | | 0.10[3] | |
| Mercury (Alkyl) | | | 0.0015[1] | 0.01 |
| Mercury | Drager(vapour) | 0.1 - 2 | 0.005[1] | 0.05 |
| | MSA | 0.05 - 2.0 | | |
| | Kitagawa | 0.1 - 2.0 | | |
| Methacrylic Acid | | | 2.0[3] | |
| Methanediphenyldiisocyanate | | | 0.003[2] | |
| Methoxychlor | | | 0.10[3] | 10 |
| Methyl Acrylate | | | 0.004[1] | 35 |
| Methyl Alcohol | Drager | 131 - 3,926 | 84[1] | 260 |
| | Gastec | 133 - 59,850 | | |
| | MSA | 1.33 - 13,300 | | |
| | Kitagawa | 130 - 78,000 | | |
| Methyl Bromide | Drager | 12 - 396 | 12[1] | 60 |
| | Gastec | 7.92 - 792 | | |
| | MSA | 39.6 - 396 | | |
| | Kitagawa | 20. - 2,000 | | |
| Methyl Chloride | | | 20.00[3] | |
| Methylene Chloride | Drager | 347 - 7,060 | 100[1] | 700 |
| | MSA | 353 - 9,800 | | |
| Methylene Dianiline | | | 0.003[4] | |

* more than one tube is needed for concentration range.

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|---|---|---|---|---|
| Methyl Chloroform | Drager<br>Gastec<br>MSA<br>Kitagawa | 273 - 3,836<br>546 - 2,728<br>556 - 3,890<br>8 - 2,170 | 350[1] | 1,900 |
| Methyl Isobutyl Ketone | | | 1.20[3] | 410 |
| Methyl Methacrylate | | | 0.86[1] | 410 |
| Methyl Salicylate | | | 0.3[3] | |
| 4,4-Methylene-Biz-2-Chloroaniline | | | 0.03[3] | |
| Miconazole Nitrate | | | 0.015[3] | |
| Milk Powder | | | 0.020[1] | |
| Monomethyl Amine | Gastec | 2.58 - 46.4* | 0.025[1] | 12 |
| Nickel | | | 0.005[1] | 0.1 |
| Nickel Tetra-carbonyl | Drager | 0.698 - 6.98 | 0.0015[1] | 0.035 |
| Nitric Acid | Gastec | 0.515 - 103 | 0.1[1] | 5.0 |
| Nitrilotriacetic Acid | | | 0.1[1] | |
| Nitrogen Oxides | Drager<br>Gastec<br>MSA<br>Kitagawa | 0.6 - 1,250<br>2.5 - 750*<br>0 - 56<br>1.8 - 1800 | 0.5[1] | 9 |

* more than one tube is needed for concentration range.

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|---|---|---|---|---|
| N-Propyl Alcohol | Drager<br>Gastec<br>MSA | 250 - 7,500<br>500 - 20,000<br>250 - 25,000 | 48.0$^3$ | |
| Ozone | Drager<br>Gastec<br>MSA | 0.1 - 600*<br>0.1 - 6<br>0.1 - 10 | 0.2$^1$ | 0.2 |
| Penicillin | | | 0.0003$^3$ | |
| Pentaborane | MSA | 0.0258 - 258 | 0.003$^1$ | 0.010 |
| Pentachlorophenol | | | 0.09$^1$ | 0.5 |
| Perchlorethylene | Drager<br>Gastec<br>MSA | 30 - 96,600*<br>30 - 1,400<br>69 - 2,760 | 10.0$^3$ | |
| Phenol | Drager | 19 | 0.10$^1$ | 19 |
| Phosgene | Drager<br>Gastec<br>MSA<br>Kitagawa | 0.2 - 310*<br>0.4 - 371<br>0.4 - 40<br>0.2 - 200* | 0.13$^1$ | 0.4 |
| Phosphoric Acids | | | 0.1$^1$ | 1 |
| Phosphorous Pentachloride | | | 0.03$^3$ | |
| Phthalic Anhydride | | | 0.1$^1$ | 6 |
| Pimozide Polychlorinated Biphenyls | | | 0.0003$^4$<br>0.00045$^2$ | |
| Polychloroprene | | | 0.1$^3$ | |
| Propionic Acid | | | 0.1$^3$ | |

* more than one tube is needed for concentration range.

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|---|---|---|---|---|
| Propionic Anhydride | | | 0.1[3] | |
| Propylene Dicholoride | MSA | 115 - 2,310 | 2.4[1] | 350 |
| Propylene Oxide | Gastec | 7,120 - 85,400 | 78[1] | 240 |
| Respirable Silica | | | 0.015[3] | |
| Selenium | | | 0.020[3] | 0.2 |
| Silver | | | 0.003[1] | 0.01 |
| Styrene | Drager | 213 - 1,700 | 0.4[1] | 420 |
| | Gastec | 43.5 - 4,350 | | |
| | MSA | 4.35 - 3,920 | | |
| | Kitagawa | 21 - 1,260 | | |
| Sulphation | | | | |
| Sulphur Dioxide | Drager | 2.62 - 1,310* | 0.830[1] | 13 |
| | Gastec | 2.62 - 209,000* | | |
| | MSA | 2.62 - 1,048 | | |
| | Kitagawa | 2.5 - 75,000* | | |
| Sulphuric Acid | | | 0.1[1] | 1 |
| Suspended Particulate Matter | | | 0.1[1] | |
| Talc (fibrous) | | | 0.005[3] | |
| Tellurium | | | 0.03[1] | 0.1 |
| Tetrahydrofuran | Drager | 90 - 1200 | 93[1] | 590 |
| | Gastec | 300 -24,000 | | |
| Tetramethyl-thiuramdisulphide | | | 0.03[3] | |

* more than one tube is needed for concentration range.

1. Design Standard
2. Tentative Design Standard
3. Guideline values
4. Provisional Guidelines

| Contaminant | Available Sampling | Concentration Range mg/m$^3$ | Ontario Environmental Limit mg/m$^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit mg/m$^3$ |
|---|---|---|---|---|
| Tin | | | 0.03[1] | 0.1 |
| Titanium | | | 0.1[1] | 10 |
| Tolmetin Sodium | | | 0.015[4] | |
| Toluene | Drager | 19.2 - 7,142* | 2.0[1] | 375 |
| | Gastec | 38.4 - 32,640* | | |
| | MSA | 38.4 - 3,072 | | |
| | Kitagawa | 37.5 - 1,875 | | |
| Toluene Diisocyanate | Drager | 0.14 - 1.4 | 0.001[1] | 0.14 |
| Total Barium in Water Soluble Cmpds. | | | 0.03[3] | |
| Total reduced Sulphur | | | 0.04[4] | |
| 1,2,4-Trichlorobenzene | | | 0.1[3] | |
| Trichloroethylene | Drager | 54 - 2,200 | 85[1] | 535 |
| | Gastec | 11.0 - 3,070* | | |
| | MSA | 137 - 3,290 | | |
| | Kitagawa | 53.5 - 3,210 | | |
| Trifluorotrichloro Ethane | MSA | 779 - 31,200 | 2,400[1] | 7,800 |
| Trimethyl Amine | | | 0.0005[3] | |
| Tripropyltin Methacrylate | | | 0.003[3] | |
| Vanadium | | | 0.005[1] | 0.5 |
| Vinyl Chloride | Drager | 1.3 - 130 | 0.560[3] | |
| | Gastec | .65 - 52,000 | | |
| | MSA | 1.3 - 260 | | |
| | Kitagawa | 1.0 - 20,000* | | |

* more than one tube is needed for concentration range.

1. Design Standard
2. Tentative Design Standard
3. Guideline values
4. Provisional Guidelines

| Contaminant | Available Sampling | Concentration Range mg/m$^3$ | Ontario Environmental Limit mg/m$^3$ (½ hour average) | Threshold Limit Value (TLV) (Occup.) Limit mg/m$^3$ |
|---|---|---|---|---|
| Vinylidene Chloride | Drager | 400 - 1,200 | 26[1] | 40 |
| | Gastec | 3.2 - 64.6 | | |
| | MSA | 20.2 - 2,020* | | |
| Xylenes | Drager | 110 - 8,250 | 2.3[1] | 435 |
| | Gastec | 44 - 2,200 | | |
| | MSA | 44 - 3,550 | | |
| | Kitagawa | 110 - 4,350 | | |

* more than one tube is needed for concentration range.

1. Design Standard
2. Tentative Design Standard
3. Guideline values
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# APPENDIX II

The following is a list of the indicator tubes which have received NIOSH certification as of June 1st, 1980.

## NOISH CERTIFIED GAS DETECTOR TUBE UNITS

| Calibrated for | Certification | Manufacturer | Model Tube/Pumps |
|---|---|---|---|
| Acetone | * TC-84-054 | MSA | 460423/83499 or 463998 |
| Ammonia | * TC-84-023 | Gastec | 3M/400 |
| Ammonia | * TC-84-031 | Drager | CH20501/31 |
| Ammonia | * TC-84-032 | Kitagawa | 105Sc/400 |
| Ammonia | * TC-84-033 | Kitagawa | 105c/400 |
| Ammonia | * TC-84-034 | MSA | 460103/83499 or 463998 |
| Benzene (A) | * TC-84-043 | Gastec | 121/400 |
| Benzene (A) | * TC-84-044 | Drager | 67-28071/31 |
| Carbon Dioxide | TC-84-021 | Gastec | 2L/400 |
| Carbon Dioxide | TC-84-025 | MSA | 85976/83499 or 463998 |
| Carbon Dioxide | TC-84-026 | Kitagawa | 126Sa/400 |
| Carbon Dioxide | TC-84-027 | Kitagawa | 126a/400 |
| Carbon Dioxide | TC-84-029 | Drager | CH23501/31 |
| Carbon Disulfide | * TC-84-066 | Drager | 67-28351/31 |
| Carbon Monoxide (A) | TC-84-012 | Drager | CH25601/31 |
| Carbon Monoxide (A) | TC-84-013 | Drager | CH20601/31 |
| Carbon Monoxide (A) | TC-84-014 | Gastec | 1La/400 |
| Carbon Monoxide (A) | TC-84-015 | MSA | 91229/83499 or 463998 |
| Carbon Monoxide (A) | TC-84-019 | Kitagawa | 106S/400 |
| Carbon Monoxide (A) | TC-84-045 | Kitagawa | 100/400 |
| Carbon Monoxide (A) | TC-84-067 | MSA | 465519/83499 or 463998 |
| Carbon Monoxide (B) | TC-84-013 | Drager | CH20601/31 |
| Carbon Monoxide (B) | TC-84-067 | MSA | 465519/83499 or 463998 |
| Carbon Tetrachloride | TC-84-036 | Gastec | 134/400 |
| Chlorine | * TC-84-041 | Gastec | 8La/400 |
| Chlorine | * TC-84-042 | MSA | 460225/83499 |
| Chlorine | * TC-84-070 | Drager | 67-28411/31 |
| Ethyl Benzene | * TC-84-064 | Drager | 67-28381/31 |
| Ethylene Dichloride | * TC-84-058 | MSA | 41863/83499 or 463998 |
| Hexane (normal) | * TC-84-063 | Drager | 67-28391/31 |
| Hydrogen Chloride | TC-84-071 | Drager | CH29501/31 |
| Hydrogen Cyanide | TC-84-051 | Drager | CH25701/31 |
| Hydrogen Cyanide | * TC-84-052 | Kitagawa | 112Sb/400 |
| Hydrogen Cyanide | * TC-84-068 | Gastec | 12 L/400 |
| Hydrogen Sulfide (A) | TC-84-020 | Gastec | 4LL/400 |
| Hydrogen Sulfide (A) | TC-84-022 | MSA | 460058/83499 or 463998 |
| Hydrogen Sulfide (A) | TC-84-024 | Drager | 67-19001/31 |
| Hydrogen Sulfide (A) | TC-84-037 | Kitagawa | 120b/400 |
| Hydrogen Sulfide (B) | TC-84-062 | Drager | CH29801/31 |
| Hydrogen Sulfide (B) | TC-84-072 | MSA | 463875/83499 or 463998 |
| Methyl Bromide | * TC-84-056 | Drager | 67-28211/31 |
| Methylene Chloride | * TC-84-061 | Drager | 67-28331/31 |
| Nitric Oxide | * TC-84-048 | Drager | CH31001/31 |
| Nitric Oxide | * TC-84-049 | Gastec | 10/400 |
| Nitric Oxide | * TC-84-059 | MSA | 460424/83499 or 463998 |

## NOISH CERTIFIED GAS DETECTOR TUBE UNITS

| Calibrated for | Certification | Manufacturer | Model Tube/Pump(s) |
|---|---|---|---|
| Nitrogen Dioxide | * TC-84-016 | Drager | CH30001/31 |
| Nitrogen Dioxide | * TC-84-018 | Gastec | 9L/400 |
| Nitrogen Dioxide | * TC-84-040 | MSA | 83099/83499 or 463998 |
| Nitrogen Dioxide | * TC-84-048 | Drager | CH31001/31 |
| Perchloroethylene | * TC-84-065 | MSA | 460467/83499 or 463998 |
| Sulfur Dioxide | * TC-84-017 | Gastec | 5La/400 |
| Sulfur Dioxide | TC-84-028 | Kitagawa | 103Sd/400 |
| Sulfur Dioxide | TC-84-030 | Drager | CH31701/31 |
| Sulfur Dioxide | TC-84-035 | Kitagawa | 103d/400 |
| Sulfur Dioxide | TC-84-046 | MSA | 92623/83499 or 463998 |
| Sulfur Dioxide | TC-84-069 | Drager | 67-28491/31 |
| Toluene | TC-84-050 | Drager | CH23001/31 |
| Toluene | TC-84-053 | Gastec | 122/400 |
| Toluene | TC-84-057 | MSA | 461371/83499 or 463998 |
| Trichloroethylene | TC-84-038 | Gastec | 132H/400 |
| Trichloroethylene | TC-84-039 | Drager | CH24401/31 |
| Trichloroethylene | TC-84-055 | MSA | 460328/83499 or 463998 |
| Vinyl Chloride | TC-84-060 | Gastec | 131L/400 |

* The unit indicates a general class of compounds (amines, hydrocarbons, strong oxidants, etc.) to differing degrees. The calibration is certified only for the compound listed.

# APPENDIX III

## Equipment Description

### The Draeger Sampler

The Draeger gas detector kit utilizes a hand-operated belows pump to which the indicator tube is fitted. The pump can be operated with one hand and supplies a constant volume (100 $cm^3$) with each stroke. The rate of flow through the tube depends upon the resistance inherent within the tube. The pump is constructed of neoprene rubber bellows, rigid polymer holding plates and stainless steel springs. A compact metal carrying case is also included.

### The Mine Safety Appliance Sampler

The Mine Safety Appliance (MSA) tester kit employs a hand-operated, piston-type pump which draws the test atmosphere through an attached tube. It has a variable-orifice which offers a selection of 4 different flow rates depending upon the specifications of the sampler tube. The pump also has a variable volume feature which allows the operator to measure 25, 50, 75 or standard 100 ml. samples. The pump must be kept completely free of dirt and gritty particles which may score the piston-cylinder walls and cause vacuum leaks. This pump and its accessories come in a portable metal carrying case. This system requires two hands to operate.

## The Gastec Sampler

A piston-type pump is also employed by Gastec. The sample volume is 100 $cm^3$ per stroke although half strokes of 50 $cm^3$ are possible when required. The pump features a lock stops assembly which ensures reproducible sample volumes. Two handed operation is necessary.

The pump itself is made of aluminum and comes in a plastic case.

## The Kitagawa Sampler

The Kitagawa sampler is similar to both the Gastec and MSA piston pumps. It draws 100 $cm^3$ of sample for each stroke. Accessory parts include limiting orifice, rubber inlet flange set, lubricants and 10 meter extention hose. This piston pump also requires two-handed operation.

## References

1) Saltzmann, Bernard E., Direct Reading Colourimetric Indicators, Air Sampling Instruments for evaluation of atmospheric contaminants 5th edition c 1978 p. S-2.

2) ibid p. 5-3

3) Colen, Frederick H.; A Study of the Interchangeability of Gas Detector Tubes and Pumps, Amer. Ind. Assoc. J. 35:694 (Nov. 1974)

4) ibid 35:690

5) Leichnitz, K.R., Detector Tubes and Prolonged Air Sampling, National Safety News p. 59 (Apr., 1977).

6) Saltzmann, Bernard E. Direct Reading Colourimetric Indicators, Air Sampling Instruments for evaluation of atmospheric contaminants 5th edition
c 1978 p. S-9

7) ibid p. S-9

8) Leichnitz, K.R., Use of Detector Tubes Under Extreme Conditions (humidity, pressure, temperature), Amer. Ind. Assos. J.
38:710 (Dec., 1977)

9) ibid p. 709

10) ibid p. 709

11) Roper, Paul; The NIOSH Detector Tube Certification Program, Amer. Ind. Assoc. J.
35:439 (July, 1974)

12) ibid 35:441 (July, 1974)

**TD**
**193**
**.S55**
**1981**

Direct reading tubes : a guide to their use and applicability in the measurement of hazardous contaminants / Smith, Jim J.
5258